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(54) Title: METHOD AND APPARATUS FOR AVOIDING UNNECESSARY RETRANSMISSIONS IN A CELLULAR MOBILE RADIO SYSTEM

(57) Abstract: The present invention relates to retransmissions in a com-munications system, and more especially it relates to avoidance of unnecessary retransmissions in a cellular mo-bile radio sys-tem, particularly in a Universal Mobile Tele-communications System, UMTS. Multiple requests for re-transmission from different link layer sub-layers are pre-vented until a failure occurs.

METHOD AND APPARATUS FOR AVOIDING UNNECESSARY RETRANSMISSIONS IN A CELLULAR MOBILE RADIO SYSTEM

TECHNICAL FIELD OF THE INVENTION

The present invention relates to retransmissions in a communications system, and more especially it relates to a cellular mobile radio system, particularly to a Universal Mobile Telecommunications System, UMTS or WCDMA system.

BACKGROUND AND DESCRIPTION OF RELATED ART

Retransmission of data to or from a mobile station, MS, or user equipment, UE, is previously known. It is also known to use medium access control and radio link control layers of a UMTS protocol structure in acknowledged mode for dedicated channels.

In acknowledged mode, retransmissions are undertaken in case of detected transmission errors not recovered by forward error control. This is also called automatic repeat request, ARQ. With ARQ, retransmissions can be undertaken unless a transmitted message is (positively) acknowledged or if it is negatively acknowledged. Generally there are time limits for the respective positive and negative acknowledgements to be considered.

Within this patent application, a radio network controller, RNC, is understood as a network element including a radio resource controller. Node B is a logical node responsible for radio transmission/reception in one or more cells to/from a User Equipment. A base station, BS, is a physical entity representing Node B.

Medium access control, MAC, and radio link control, RLC, are used within radio communications systems like General Packet Radio Services, GPRS, and UMTS.

U.S. Patent US5222061 describes a data services retransmission procedure to control unnecessary multiple retransmissions of a data packet by tracking the sequence numbers of transmitted packets. The data packet is retransmitted if it appears in the list prior to the last data packet that is received correctly. Upon retransmission, the sequence numbers of the list are rearranged. A receiver transmits a status control message to a transmitter periodically. The patent recognizes that the receiver may have correctly received a packet, which was included in a status control message.

U.S. Patent US6118765 also recognizes that a receiver may have correctly received a packet, multiply requested for retransmission, after a first retransmission. The patent discards unnecessarily transmitted data packets prior to packet forwarding.

3rd Generation Partnership Project (3GPP): *Technical Specification Group Radio Access Network, Physical Layer Procedures, 3G TS 25.301 v3.6.0, France, September 2000,* specifies in chapter 5 Radio Interface Protocol Architecture of a UMTS system. There are three protocol layers:

- physical layer, layer 1 or L1,
- data link layer, layer 2 or L2, and
- network layer, layer 3 or L3.

Layer 2, L2, and layer 3, L3 are divided into Control and User Planes. Layer 2 consists of two sub-layers, RLC and MAC, for the Control Plane and four sub-layers, BMC, PDCP, RLC and MAC, for the User Plane. The acronyms BMC, PDCP, RLC and MAC denote Broadcast/Multicast Control, Packet Data Convergence Protocol, Radio Link Control and Medium Access Control respectively.

Figure 1 illustrates a simplified UMTS layers 1 and 2 protocol structure for a Uu Stratum, UuS, or Radio Stratum, between a user equipment UE and a Universal Terrestrial Radio Access Network, UTRAN.

Radio Access Bearers, RABs, make available radio resources (and services) to user applications. For each mobile station there may be one or several RABs. Data flows (in the form of segments) from the RABs are passed to respective Radio Link Control, RLC, entities which amongst other tasks buffer the received data segments. There is one RLC entity for each RAB. In the RLC layer, RABs are mapped onto respective logical channels. A Medium Access Control, MAC, entity receives data transmitted in the logical channels and further maps logical channels onto a set of transport channels. In accordance with subsection 5.3.1.2 of the 3GPP technical specification MAC should support service multiplexing e.g. for RLC services to be mapped on the same transport channel. In this case identification of multiplexing is contained in the MAC protocol control information.

Transport channels are finally mapped to a single physical channel which has a total bandwidth allocated to it by the network. In frequency division duplex mode, a physical channel is defined by code, frequency and, in the uplink, relative phase (I/Q). In time division duplex mode a physical channel is defined by code, frequency, and timeslot. The DSCH, e.g., is mapped onto one or several physical channels such that a specified part of the downlink resources is employed. As further described in subsection 5.2.2 of the 3GPP technical specification the L1 layer is responsible for error detection on transport channels and indication to higher layer, FEC encoding/decoding and interleaving/deinterleaving of transport channels.

PDCP provides mapping between Network PDUs (Protocol Data Units) of a network protocol, e.g. the Internet protocol, to an RLC entity. PDCP compresses and decompresses redundant Network PDU control information (header compression and decompression).

For transmissions on point-to-multipoint logical channels, BMC stores at UTRAN side Broadcast Messages received from an RNC, calculates the required transmission rate and requests for the appropriate channel resources. It receives scheduling information from the RNC, and generates schedule messages. For transmission the messages are mapped on a point-to-multipoint logical channel. At the UE side, BMC evaluates the schedule messages and deliver Broadcast Messages to upper layer in the UE.

3G TS 25.301 also describes protocol termination, i.e. in which node of the UTRAN the radio interface protocols are terminated, or equivalently, where within UTRAN the respective protocol services are accessible.

3rd Generation Partnership Project (3GPP): *Technical Specification Group Radio Access Network, Physical Layer Procedures, 3G TS 25.322 v3.5.0, France, December 2000,* specifies the RLC protocol. The RLC layer provides three services to the higher layers:

- transparent data transfer service,
- unacknowledged data transfer service, and
- acknowledged data transfer service.

In subsection 4.2.1.3 an acknowledged mode entity, AM-entity, is described (see figure 4.4 of the 3GPP Technical Specification). In acknowledged mode automatic repeat request, ARQ, is used. The RLC sub-layer provides ARQ functionality closely coupled with the radio transmission tech-

nique used. The 3GPP technical specification also reveals various triggers for a status report to be transmitted. The receiver shall always send a status report, if it receives a polling request. There are also three status report triggers, which can be configured

1. Missing PU(s) Detected,
2. Timer Initiated Status Report, and
3. Estimated PDU Counter.

For trigger 1, the receiver shall trigger transmission of a status report to the sender if a payload unit, PU, is detected to be missing. (One PU is included in one RLC PDU.) With trigger 2, a receiver triggers transmission of a status report periodically according to a timer. Finally, trigger 3 relates in short to a timer corresponding to an estimated number of received PUs before the requested PUs are received.

None of the cited documents above discloses a method and system of eliminating unnecessary retransmissions for a layered protocol structure, for which two or more sublayers can request retransmissions.

SUMMARY OF THE INVENTION

Cited prior art references describe retransmissions between a UE and an RNC. According to preferred embodiments of the invention retransmissions are terminated in Node B and UE respectively.

Only specified transmission units are allowed for retransmissions in UMTS. According to the invention, a transmission unit preferably comprises one slot. Each transmission unit is composed of one or more transport blocks, TBs. Each TB comprises one or more protocol data units, PDUs.

If a transmission unit contains one or more errors, L2 MAC layer of the receiving side protocol preferably requests retransmission of that transmission unit, including all TBs it carries. Retransmitted TBs will arrive after a delay due to propagation and processing time.

The following scenario illustrates the concept of unnecessary retransmissions: L2 MAC layer delivers PDUs of correctly received TBs to L2 RLC layer. The L2 RLC layer identifies PDUs of TBs for which MAC-layer retransmission has been requested, but not yet arrived, as missing. The RLC generates status reports as prescribed in 3GPP Technical Specification 25.322. For this reason, PDUs may be requested for retransmission by both the MAC and the RLC sublayers. If a transmission unit, retransmitted upon request at L2 MAC layer, contains no errors upon arrival, the RLC request for retransmission of the PDUs carried by the transmission unit is unnecessary. Unnecessary retransmissions cause excessive delay and waste of channel capacity.

Consequently, an object of this invention is to eliminate unnecessary RLC-retransmissions.

It is also an object to present a method of consecutive packet delivery of packets to the RLC layer.

A further object is to keep track of PDUs included in retransmitted TBs but not received at RLC sub-layer at the time for initiation of the RLC status report.

Finally, it is an object to only retransmit PDUs at RLC sub-layer if the latest TB-transmission including the PDUs have been received in time to be considered when establishing the RLC status report.

These objects are met by a method and system of retransmissions such that only one of the MAC and RLC sub-layers is

responsible for retransmission of a particular PDU at a particular instance.

A first embodiment meets the objects with a highly limited requirement on buffer sizes in L2 MAC layer. A second embodiment benefits from a relaxed requirement on indicator transfer between L2 sub-layers. A third embodiment of the invention further benefits from a shortened retransmission delay of missing PDUs at L2 MAC failure.

The invention is particularly well suited for a high-speed downlink packet access channel of an evolved universal mobile telecommunications system.

Preferred embodiments of the invention, by way of examples, are described with reference to the accompanying drawings below.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 displays a layered protocol structure, according to prior art, in a radio communications system.

Figure 2 shows communication, according to the invention, between a UE and a base station involved in a connection between an RNC and the UE.

Figure 3 schematically illustrates MAC and RLC protocol layers, according to the invention, in a multilayer protocol structure.

Figure 4 schematically illustrates slots and transport blocks versus time on a physical channel, according to the invention.

Figure 5 graphically illustrates status report establishment for RLC PDUs delayed in a MAC layer, according to a first embodiment of the invention.

Figure 6 shows a flow chart of L1 and L2 MAC layer operations on a received transmission unit according to the first embodiment of the invention.

Figure 7 shows RLC PDUs as accepted in a MAC layer and as received in a higher RLC layer, according to a second embodiment of the invention.

Figure 8 depicts RLC PDUs as accepted in a MAC layer and as received in a higher RLC layer, according to a third embodiment of the invention.

Figure 9 shows a flow chart of L1 and L2 MAC layer operations on a received transmission unit according to the second embodiment of the invention.

Figure 10 shows a flow chart of L1 and L2 MAC layer operations on a received transmission unit according to the third embodiment of the invention.

Figure 11 illustrates an apparatus according to the first embodiment of the invention.

Figure 12 displays an apparatus according to the second and third embodiments of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

With reference to figure 2, Node B 1 and Node B 2 are logical nodes responsible for radio transmission/reception in one or more cells to/from the User Equipment UE. BS 1 and BS 2 are physical entities representing Node B 1 and Node B 2 respectively. Node B 1 and Node B 2 terminate the air interface, called Uu interface within UMTS, between UE and respective Node B towards the radio network controller RNC. In UMTS the interface between a Node B and an RNC is called Iub interface.

In an exemplary situation UE communicates over a radio link associated with BS 1. Packet switched data is transmitted in protocol data units, PDUs, in both directions. Each PDU is transported on a transport channel in a transport block, TB. As described above, transmission errors on the transport channel are corrected and detected by layer L1 of figures 1 and 3. Each transport block, TB, in figure 3 can be provided an individual CRC error-detecting checksum prior to transmission on the physical channel. However, preferably a transmission unit, carrying one or more TBs, is provided only one CRC error-detecting checksum. If a transmission unit is detected to be in error on the receiving side, this is reported to the L2 MAC layer.

L2 MAC layer can request retransmission of transmission units received in error. Transmission units detected to be in error still carry information that should not be wasted. Preferably hybrid ARQ, utilizing information available from earlier transmission(s) of a transmission unit by proper combining with the latest retransmission, is used prior to an L2 MAC layer request for retransmission.

Error detection, at the receiving end, is also performed by layer L2 RLC of figure 3. If an RLC protocol data unit, PDU, is received in error and the error is not recovered by forward error correction of the PDU or the PDU is missing, it will be requested for retransmission at a point in time when a status report is established by the RLC layer. RLC PDUs are transferred to/from the MAC layer SDUs. The MAC SDU possibly includes a header not included in the RLC PDU. As previously described, the RLC PDUs are transferred in transport blocks, TBs, on the physical channel. The L2 MAC layer transfers TBs to the L1 physical layer.

A network layer PDU or L3 PDU can comprise several RLC PDUs, as illustrated in figure 3. RLC PDUs are reassembled into RLC service data units, RLC SDU, prior to delivery to higher layer PDU. The L3 protocol can be, e.g., the Internet Protocol, IP. Upon reception from L3, RLC SDUs are segmented into RLC PDUs.

Figure 4 illustrates three out of a plurality of time slots on a physical channel, each slot representing a transmission unit. For illustrative purposes each of the time slots, Slot1, Slot2 and Slot3, is indicated to carry three transport blocks and a CRC checksum, TB1–TB3 & CRC1, TB4–TB6 & CRC2 and TB7–TB9 & CRC3 respectively. The present invention avoids unnecessary retransmissions of slots/retransmission units carrying transport blocks and the RLC PDUs included therein, in compliance with transmitted data and overhead.

In an evolved WCDMA system, a high-speed downlink packet access channel, HSDPA channel, is a channel with similarities to a DSCH. However, it is based on a novel transport channel type. An HSDPA channel supports many new features not supported by DSCH, but also inherits some of the characteristics of a DSCH. There are several important features of an HSDPA channel. A sample of features is:

- High data rates with peak data rates up to tens of Mbit/s.
- Data is transmitted to multiple users on a shared channel by means of time-division multiplex, TDM.
- Higher-order modulation.

- Fast retransmission with soft combining of retransmitted data at UE, also referred to as Fast Hybrid ARQ or Fast HARQ.
- Low air-interface delay, with maximum round-trip delay down to some ten milliseconds.

It is preferred that the Fast Hybrid ARQ is terminated in Node B.

According to a first preferred embodiment, as explained in relation to figure 5, to all RLC PDUs, received by the MAC layer, an indicator is attached. It indicates to the L2 RLC layer if the RLC PDU is included in a request for retransmission at the MAC layer. Retransmission is initiated at the MAC layer if, in a set of transport blocks included in a transmission unit, an error was detected at decoding. In figure 5, the indicator used is "delayed." Of course, any appropriate indicator could be used for this purpose. In figure 5, retransmission units carrying RLC PDUs 1, 2, 3, 13 and 14 are indicated as being requested for retransmission. Consequently these RLC PDUs are delayed. Transport blocks carrying RLC PDUs 4, 5, 6, 10, 11 and 12 have been received and indicated to be error-free according to the CRC checksum. RLC PDUs 7, 8 and 9 have not been correctly received and no request for retransmission has been transmitted to the transmitting side for these PDUs. They are indicated by "failed." There could be various reasons for PDUs 7, 8 and 9 not being requested for retransmission. One reason could be the slot number of the slot, forming the transmission unit, carrying the PDUs has been corrupted during transfer. A failure during retransmission request could be another reason. Failed retransmissions, as those for RLC PDUs 7, 8 and 9, should be taken care of by L2 RLC layer. However, delayed RLC PDUs are already being retransmitted and should not be

requested also by the L2 RLC layer, for unnecessary retransmissions to be avoided, unless the MAC layer indicates a failure. Consequently, according to a first embodiment of the invention RLC PDUs indicated to be delayed that have not yet arrived will be requested for retransmission only if L2 MAC layer indicates a failure prior to arrival of the delayed RLC PDUs. With reference to figure 5, RLC PDUs 1, 2 and 3 will not be included in an RLC status report (i.e. they will not be requested for retransmission by L2 RLC layer) if the status report is established prior to the point in time when a MAC failure is indicated for RLC PDUs 7, 8 and 9. However, if a status report establishment were triggered posterior to the MAC failure, they would be included in the status report as the report will cover all PDUs not included in the previous status report and indicated to be delayed, or for which a failure has occurred. The missing RLC PDUs 7, 8 and 9 will be detected as missing upon correct reception of slots carrying RLC PDUs 10 and higher. Therefore, also RLC PDUs 7, 8 and 9 are included in the status report requesting retransmission of delayed or failed retransmission units according to the first embodiment of the invention.

Figure 6 shows a flow chart of L1 and L2 MAC layer operation on a received transmission unit according to the first embodiment of the invention. As soon as a MAC layer failure is detected this is indicated to layer L2 RLC. If no failure is detected, L2 MAC layer proceeds by checking for errors in the transmission unit. If an error detection is reported from L1 layer, L2 MAC layer initiates a request for retransmission of the transmission unit detected to be in error and indicates to L2 RLC all TBs, or corresponding RLC PDUs, requested for retransmission as being delayed.

The principle of a second and third embodiment of the invention is illustrated in figures 7 and 8. By MAC layer received and accepted as error-free TBs, possibly after retransmission, corresponding to RLC PDUs are titled "MAC arrivals." Assuming RLC PDUs originally being sent consecutively, one or more transmission units carrying RLC PDUs 1, 2, and 3 apparently have been retransmitted and arrived after the one or more slots carrying RLC PDUs 4, 5 and 6. If, upon arrival of the TB carrying RLC PDU 4, this RLC PDU (or its corresponding MAC SDU) had been transferred to the RLC prior to the arrival of RLC PDUs 1, 2 and 3, a possibly triggered status report would have indicated RLC PDUs 1, 2 and 3 as missing, including these PDUs in a request for retransmission. However, the one or more retransmission units carrying these PDUs were already requested for retransmission by the L2 MAC layer and, if correctly received, an L2 RLC request for retransmission would have been unnecessary. In the second and third embodiments unnecessary retransmissions are avoided by buffering received TBs and delivering MAC SDUs to the L2 RLC layer sequentially according to the numbering of the RLC PDUs. This will introduce a delay as compared to the first embodiment of the invention. However, the second and third embodiments benefit from not requiring a delay indicator being transferred between the MAC and RLC sub-layers. As all MAC SDUs/RLC PDUs are delivered in numerical order to the L2 RLC layer, a failure will result in one or more missing RLC PDUs at RLC layer. An L2 RLC status report similar to that of figure 5 is triggered by status triggers according to prior art. RLC PDUs missing at the time of status report establishment will be negatively acknowledged and retransmitted.

According to the third embodiment of the invention, the L2 MAC layer indicates to the L2 RLC layer a failure as

soon as detected. This is illustrated in figure 8 by the indicator "Failure" being transferred to RLC layer. When the L2 MAC layer detects a failure, it notifies the L2 RLC layer that preferably initiates establishment of a status report upon reception of this indication. Thereby, the retransmission delay for missing RLC PDUs can be reduced. According to the second embodiment of figure 7, there is no such indicator.

In figures 7 and 8 a MAC failure is detected after transmission unit carrying PDU 3 was successfully received. Upon a failure the MAC layer buffer content, if any, is transferred to the RLC layer for both the second and third embodiments.

As could be seen from the example for the second and third embodiments in figures 7 and 8, RLC PDUs 1, 2 and 3 are not included in a status report if triggered prior to the failure, as L2 RLC is not aware of any of RLC PDUs 1-6 until RLC PDU 3 has arrived, due to requirement on RLC PDUs (or corresponding MAC SDUs) being transferred from sub-layer L2 MAC to sub-layer L2 RLC in numerical order.

Thereafter, TBs carried by subsequently successfully received transmission units are buffered and corresponding PDUs transferred in numerical order to the RLC layer.

Figures 9 and 10 each show a flow chart of L1 and L2 MAC layer operations of the second and third embodiments respectively. In figures 9 and 10 a MAC failure is detected as it occurs according to a MAC failure detector. There could be various reasons for an L2 MAC failure. One reason could be the slot number of the slot, forming the transmission unit, carrying the PDUs has been corrupted during transfer. A failure during retransmission request could be another reason. For the second embodiment of

figure 9, as soon as a MAC failure is detected the entire transmission unit is skipped and the MAC layer proceeds with analyses of the next transmission unit. In the third embodiment, as soon as a MAC failure is detected the MAC layer delivers all buffered PDUs (or corresponding MAC SDUs) to the L2 RLC layer (see figure 10) accompanied by a failure indicator. Missing PDUs will be requested for re-transmission by the RLC layer, as described in relation to figures 7 and 8. With reference to figures 9 and 10, both the second and the third embodiments will transfer MAC TB-buffered RLC PDUs at particular instances to the L2 RLC layer. When the MAC buffer content has been transferred, it is cleared from the MAC buffer.

As an erroneous transmission unit (slot) is detected from the L1 CRC checksum, all transport blocks, TBs, carried by the transmission unit are preferably requested for retransmission. Of course, whenever an individual CRC checksum is applied to each TB, individual TBs of a trans-mission unit can be requested for retransmission as need be.

TBs requested for retransmission are indicated as delayed in the MAC buffer to keep track of TBs expected to arrive at a later instance. Correctly received TBs are inserted in the MAC buffer in accordance with the RLC PDU sequence number. RLC PDUs marked as delayed are replaced by their retransmissions when correctly received. As long as there are any preceding TB, or corresponding RLC PDU, marked as delayed upon insertion of a TB/PDU in the MAC buffer, the error-free TBs/PDUs are not in consecutive order and should not be transferred to the RLC layer, for unnecessary retransmissions to be avoided. Consequently, the MAC layer proceeds by processing next transmission unit. When a preset fraction of the MAC buffer is consecutively ordered

with no preceding TBs/PDUs indicated as being delayed, this fraction is transferred to the RLC layer and cleared from the MAC buffer. Preferably the content of a transmission unit is transferred to the RLC layer as soon as it is verified that it is not preceded by a delay indicator in the MAC buffer, i.e. the preferred fraction corresponds to the amount of data carried by one transmission unit.

Figure 11 illustrates a user equipment according to the first embodiment including means 1 for setting an indicator indicating an L2 MAC layer failure and for transferring the indicator to the L2 RLC layer, means 2 for setting an indicator indicating an L2 MAC layer delay and for transferring the indicator to the L2 RLC layer, means 3 for detecting in the L2 RLC layer a failure indicator being transferred from the L2 MAC layer and means 4 for detecting at the L2 RLC layer a delay indicator being transferred from the L2 MAC layer.

Figure 12 shows a user equipment operating according to the second or third embodiment including means 5 for setting an indicator in an L2 MAC buffer, the indicator indicating data units requested for retransmission at the L2 MAC layer as being delayed, means 6 for setting an indicator in an L2 MAC layer buffer, the indicator indicating L2 MAC layer failure, means 7 for insertion of a transport block in PDU-sequential order in the L2 MAC layer buffer, and means 8 for transfer of L2 MAC layer buffer to L2 RLC layer and for clearing lower level protocol layer buffer. Only buffer content of L2 MAC layer buffer actually transferred to L2 RLC layer is cleared. Consequently, if the L2 MAC buffer is only transferred in partial, buffer content corresponding to the transferred part of the MAC layer buffer is cleared from the buffer.

Corresponding means as illustrated for a user equipment in figures 11 and 12 are also applicable in a network element communicating with the user equipment if the invention is applied in uplink direction. Consequently, the described means also apply for a network element housing the receiver side ARQ-machine. In figure 2, the UTRAN-side ARQ-machine resides in a base station BS 1, representing the network element. This preferred solution does not exclude an RNC from being the network element housing the receiver-side ARQ-machine.

A person skilled in the art readily understands that the receiver and transmitter properties of a BS or a UE are general in nature. The use of concepts such as BS, UE or RNC within this patent application is not intended to limit the invention only to devices associated with these acronyms. It concerns all devices operating correspondingly, or being obvious to adapt thereto by a person skilled in the art, in relation to the invention. As an explicit non-exclusive example the invention relates to mobile stations without a subscriber identity module, SIM, as well as user equipment including one or more SIMs. Further, protocols and layers are referred to in close relation with UMTS terminology. However, this does not exclude applicability of the invention in other systems with other protocols and layers of similar functionality.

The invention is not intended to be limited only to the embodiments described in detail above. Changes and modifications may be made without departing from the invention. It covers all modifications within the scope of the following claims.

CLAIMS

1. A method of coordinating retransmission requests from two or more protocol layers in a communications system, the method characterized in that if a lower protocol layer failure is detected, this is reported to a higher protocol layer and if no lower protocol layer failure is detected, transport error information is received or calculated by the lower protocol layer.

2. The method according to claim 1 characterized in that if transport error information indicates a transmission error, retransmission is requested by the lower protocol layer and data units requested for retransmission are indicated to the higher protocol layer as being delayed.

3. The method according to claim 1 or 2 characterized in that if transport error information does not indicate a transmission error, data units received by the lower protocol layer are transferred to the higher protocol layer.

4. The method according to any of claims 1-3 characterized in that data units indicated to the higher protocol layer as being delayed are requested for retransmission by the higher protocol layer conditionally on a subsequent failure indication from the lower protocol layer.

5. The method according to claim 1 characterized in that data units detected as being missing or for which the failure indicator was received are requested for retransmission by the higher protocol layer.

6. A method of coordinating retransmission requests from two or more protocol layers in a communications system, the

method characterized in that if a lower protocol layer failure is detected, data units received during the failure are disregarded and the lower protocol layer buffer content, if any, is transferred to the higher protocol layer, and if no lower protocol layer failure is detected, transport error information is received or calculated by the lower protocol layer.

7. The method according to claim 6 characterized in that if lower protocol layer transport error information indicates a transmission error, retransmission is requested by the lower protocol layer and data units requested for retransmission are indicated as being delayed in a lower protocol layer buffer.

8. The method according to claim 6 or 7 characterized in that if lower protocol layer transport error information does not indicate a transmission error, data units received by the lower protocol layer are inserted in sequential order in a lower protocol layer buffer.

9. The method according to any of claims 6-8 characterized in that if any preceding data unit in the lower protocol layer buffer is indicated as being delayed, the lower protocol layer proceeds by processing next received transmission unit.

10. The method according to any of claims 6-8 characterized in that if no preceding data unit in the lower protocol layer buffer is indicated as being delayed, the lower protocol layer buffer content is transferred to the higher protocol layer.

11. A method of coordinating retransmission requests from two or more protocol layers in a communications system, the

method characterized in that if a lower protocol layer detects a failure, the lower protocol layer indicates the failure in a lower protocol layer buffer, and if no lower protocol layer failure is detected, transport error information is received or calculated by the lower protocol layer.

12. The method according to claim 11 characterized in that if lower protocol layer transport error information indicates a transmission error, retransmission is requested by the lower protocol layer and data units requested for retransmission are indicated as being delayed in a lower protocol layer buffer.

13. The method according to claim 11 or 12 characterized in that if lower protocol layer transport error information does not indicate a transmission error, data units received by the lower protocol layer are inserted in sequential order in a lower protocol layer buffer.

14. The method according to any of claims 11-13 characterized in that if any preceding data unit in the lower protocol layer buffer is indicated as being delayed, the lower protocol layer proceeds by processing next received transmission unit.

15. The method according to any of claims 11-13 characterized in that if no preceding data unit in the lower protocol layer buffer is indicated as being delayed, or if there is a failure indicator in the lower protocol layer buffer, the lower protocol layer buffer content is transferred to the higher protocol layer.

16. A method of coordinating retransmission requests from two or more protocol layers in a communications system, the

method characterized in that when a data unit is requested for retransmission by a lower protocol layer at the receiving side, information on the retransmission is stored in the protocol and inclusion of the data unit requested for retransmission by the lower protocol layer will not be included into a request for retransmission by a higher protocol layer unless a failure at the lower protocol layer is detected.

17. The method according to any of claims 1-16 characterized in that the request for retransmission of a data unit by the higher protocol layer is achieved by inclusion of the data unit into a status report.

18. The method according to any of claims 1-17 characterized in that a status report will be triggered by at least one of

- a failure indication from the lower protocol layer,
- missing PDU or payload unit detected,
- elapsed timer and,
- elapsed PDU counter.

19. The method according to any of claims 1-18 characterized in that in the lower protocol layer, retransmitted data is softly combined.

20. The method according to any of claims 1-19 characterized in that in the lower protocol layer, transmission units are requested for retransmission in accordance with HARQ.

21. The method according to any of claims 1-20 characterized in that the lower protocol layer is an

L2 MAC protocol layer and the higher protocol layer is an L2 RLC protocol layer in a universal mobile telecommunications system.

22. The method according to any of claims 1-21 characterized in that the transmission unit is a slot.

23. The method according to any of claims 1-22 characterized in that the transmission unit comprises one or more transport blocks.

24. The method according to any of claims 1-23 characterized in that transmissions and retransmissions are transmissions on an HSDPA channel.

25. An apparatus including means for requesting retransmission of data units carried on a communications channel in transmission units, the apparatus characterized by means for setting an indicator and transferring it to a higher protocol layer, the indicator indicating a lower protocol layer failure, and means for setting an indicator and transferring it to the higher protocol layer, the indicator indicating data units requested for retransmission at the lower protocol layer as being delayed.

26. The apparatus according to claim 25 characterized by means for detecting a failure indicator being transferred from the lower to the higher protocol layer.

27. The apparatus according to claim 25 characterized by means for detecting a delay indicator being transferred from the lower to the higher protocol layer.

28. An apparatus including means for requesting retransmission of data units carried on a communications channel in transmission units, the apparatus characterized by means for setting an indicator in a lower protocol layer buffer, the indicator indicating data units requested for retransmission at the lower protocol layer as being delayed.

29. An apparatus including means for requesting retransmission of data units carried on a communications channel in transmission units, the apparatus characterized by means for setting an indicator in a lower protocol layer buffer, the indicator indicating lower protocol layer failure.

30. The apparatus according to any of claims 25-29 characterized in that the apparatus is a user equipment of a communications system.

31. The apparatus according to any of claims 25-29 characterized in that the apparatus is a user equipment of a mobile communications system, particularly a universal mobile telecommunications system.

32. The apparatus according to any of claims 25-29 characterized in that the apparatus is a network element of a communications system.

33. The apparatus according to any of claims 25-29 characterized in that the apparatus is a network element, such as a base station or a radio network controller, of a mobile communications system, particularly a universal mobile telecommunications system.

34. Radio communications system characterized by means for carrying out the method in any of claims 1-24.

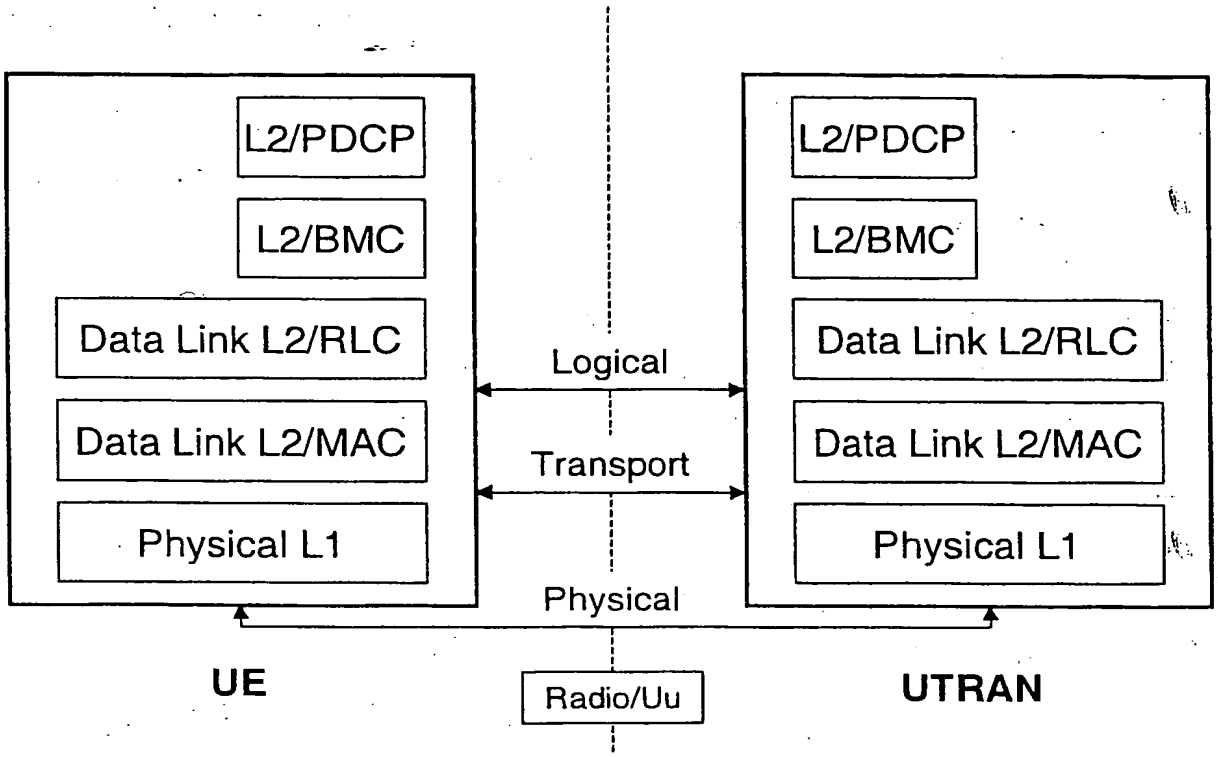
L2/PDCP
L2/BMC
Data Link L2/RLC
Data Link L2/MAC
Physical L1
Logical
Transport
Physical
L2/PDCP
L2/BMC
Data Link L2/RLC
Data Link L2/MAC
Physical L1
UE
Radio/Uu
UTRAN

Fig. 1

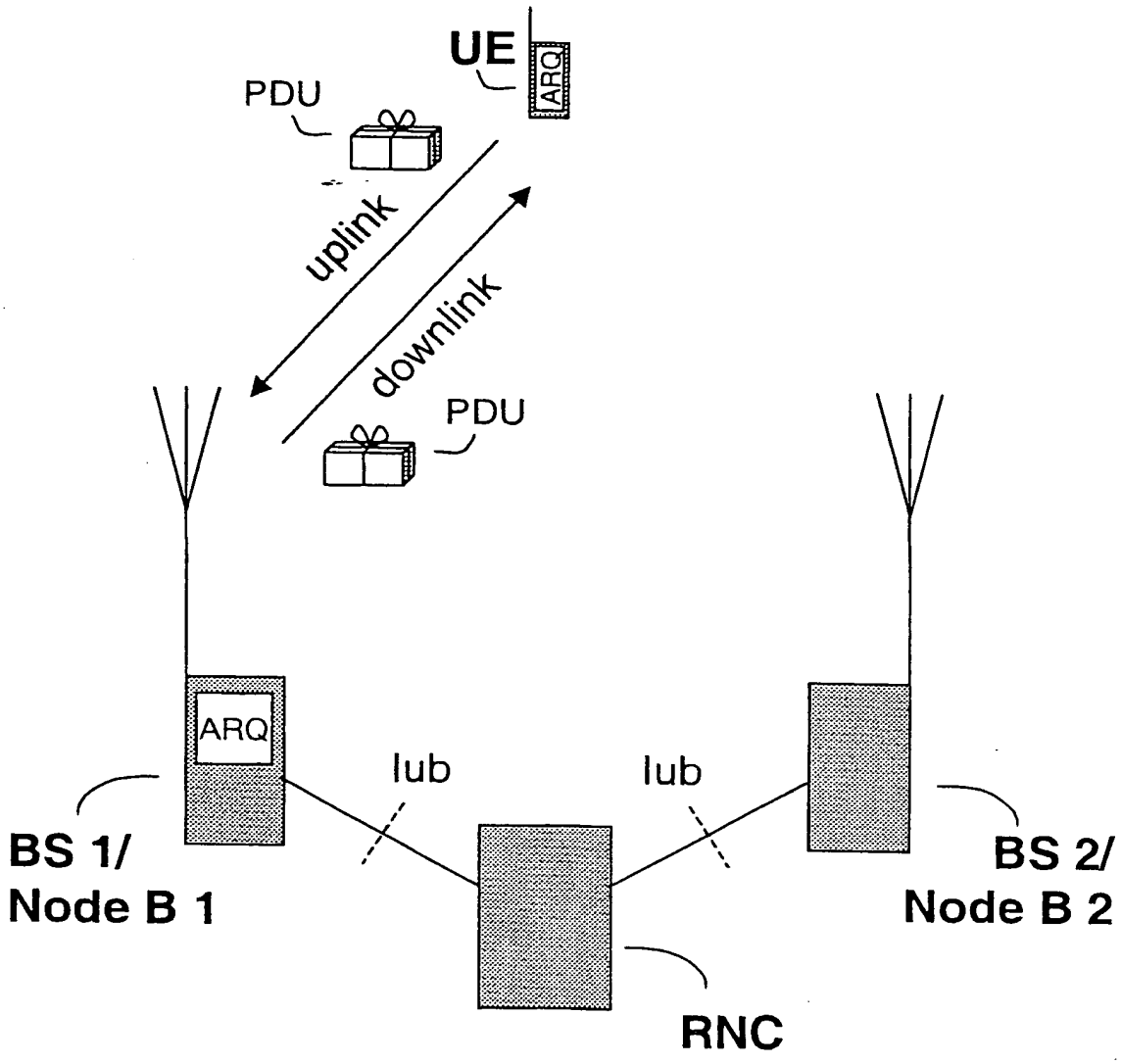
UE
ARQ
PDU
uplink
downlink
PDU
ARQ
Iub
Iub
BS 1/
Node B 1
BS 2/
Node B 2
RNC

Fig. 2

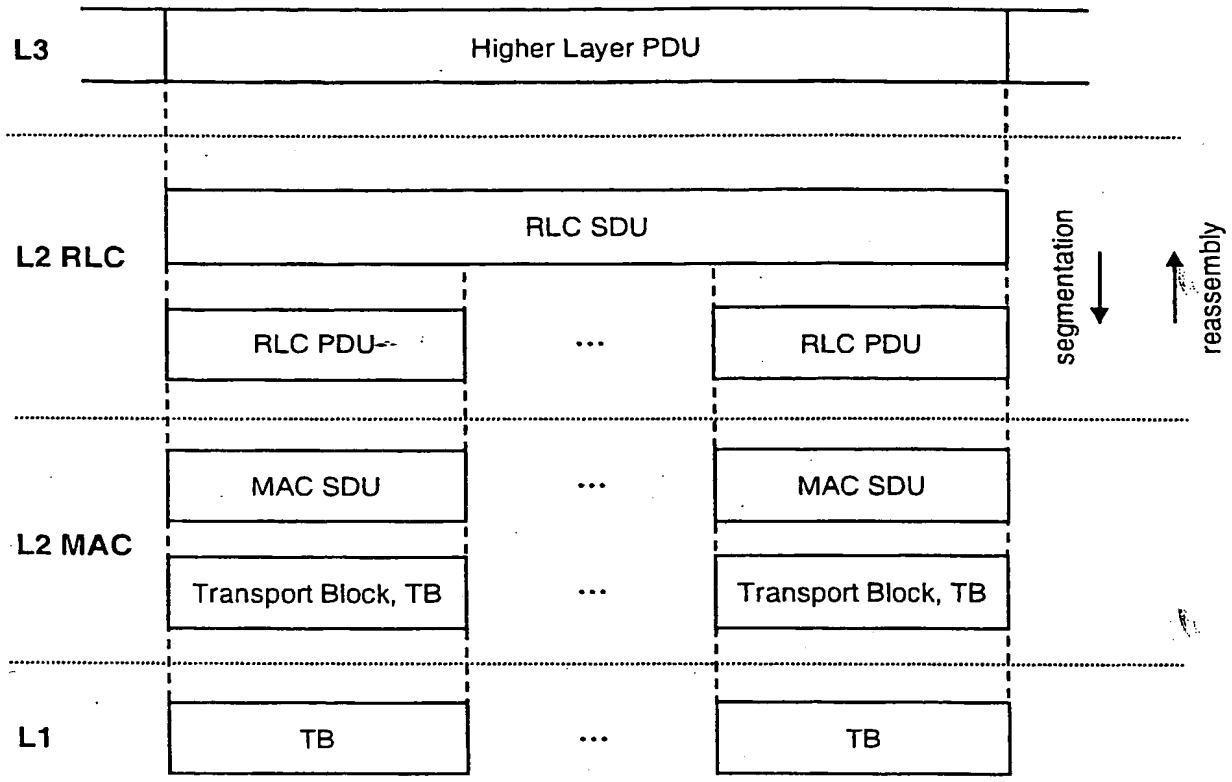
L3
Higher Layer PDU
L2 RLC
RLC SDU
RLC PDU
RLC PDU
segmentation
reassembly
L2 MAC
MAC SDU
MAC SDU
Transport Block, TB
Transport Block, TB
L1
TB
TB

Fig. 3

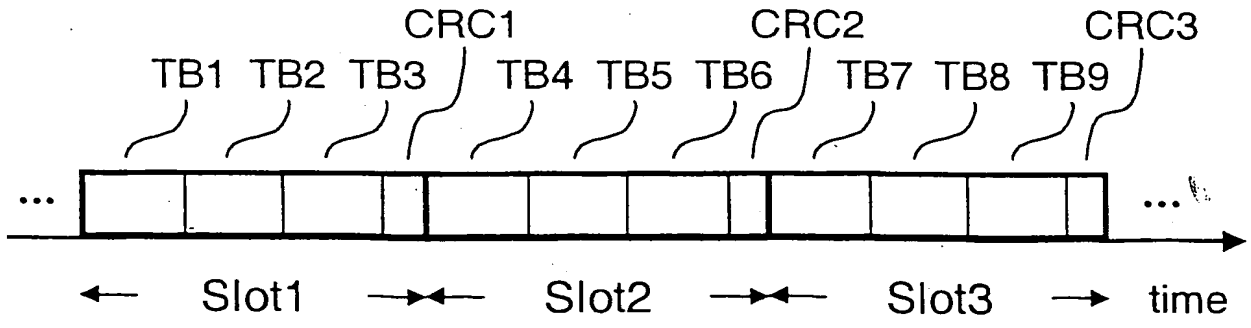
CRC1
CRC2
CRC3
TB1 TB2 TB3 TB4 TB5 TB6 TB7 TB8 TB9
Slot1
Slot2
Slot3
time

Fig. 4

MAC → RLC

PDU	Indicator
1	delayed
2	delayed
3	delayed
4	
5	
6	
7	failed
8	failed
9	failed
10	
11	
12	
13	delayed
14	delayed

STATUS REPORT

NACKed PDUs
1
2
3
7
8
9

Fig. 5

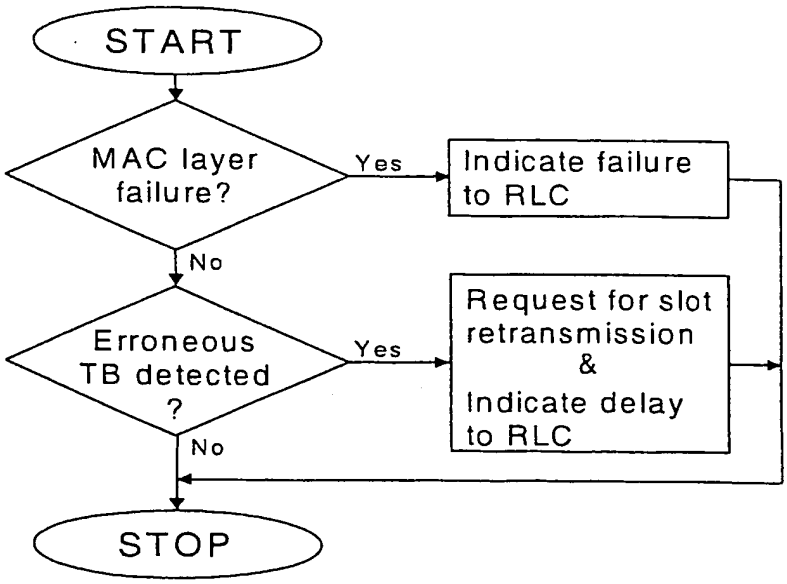

Fig. 6

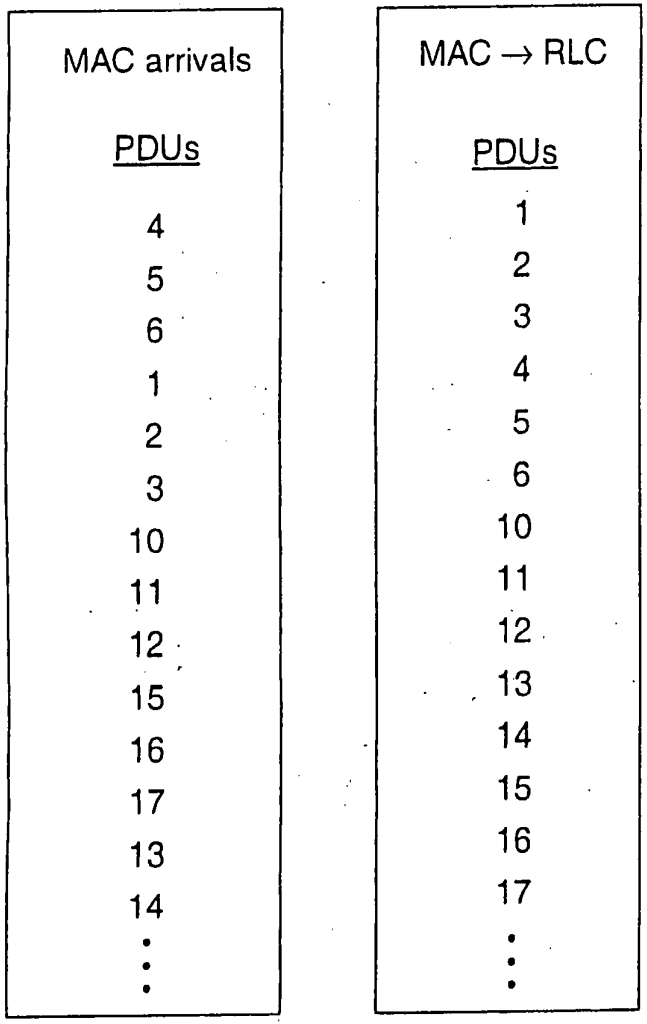
MAC arrivals
PDUs
4
5
6
1
2
3
10
11
12
15
16
17
13
14
MAC → RLC
PDUs
1
2
3
4
5
6
10
11
12
13
14
15
16
17

Fig. 7

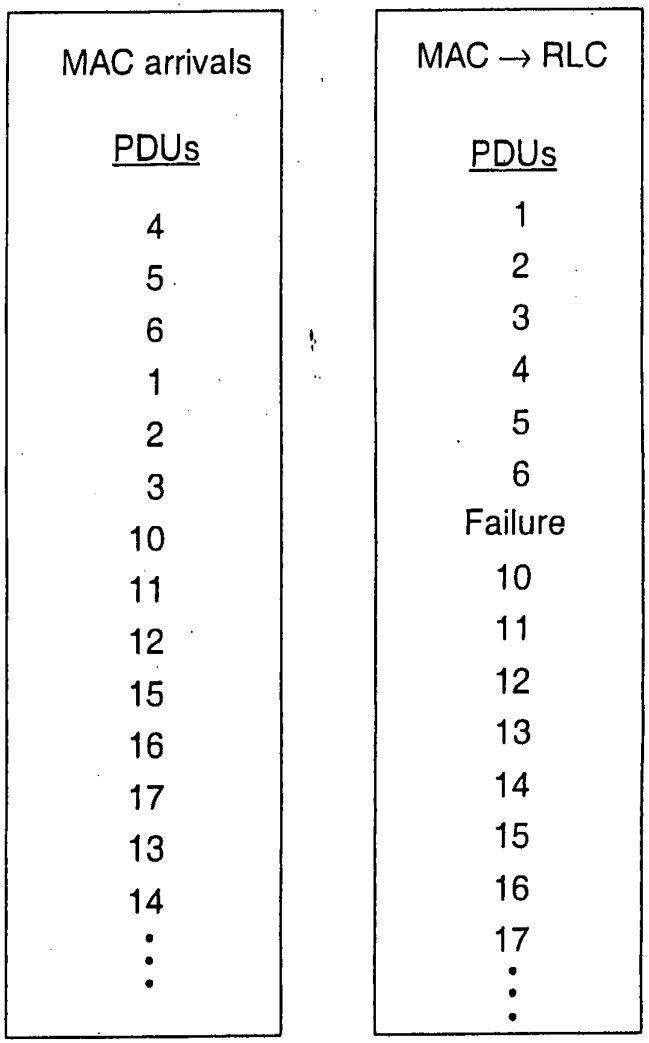
MAC arrivals
PDUs
4
5
6
1
2
3
10
11
12
15
16
17
13
14
MAC → RLC
PDUs
1
2
3
4
5
6
Failure
10
11
12
13
14
15
16
17

Fig. 8

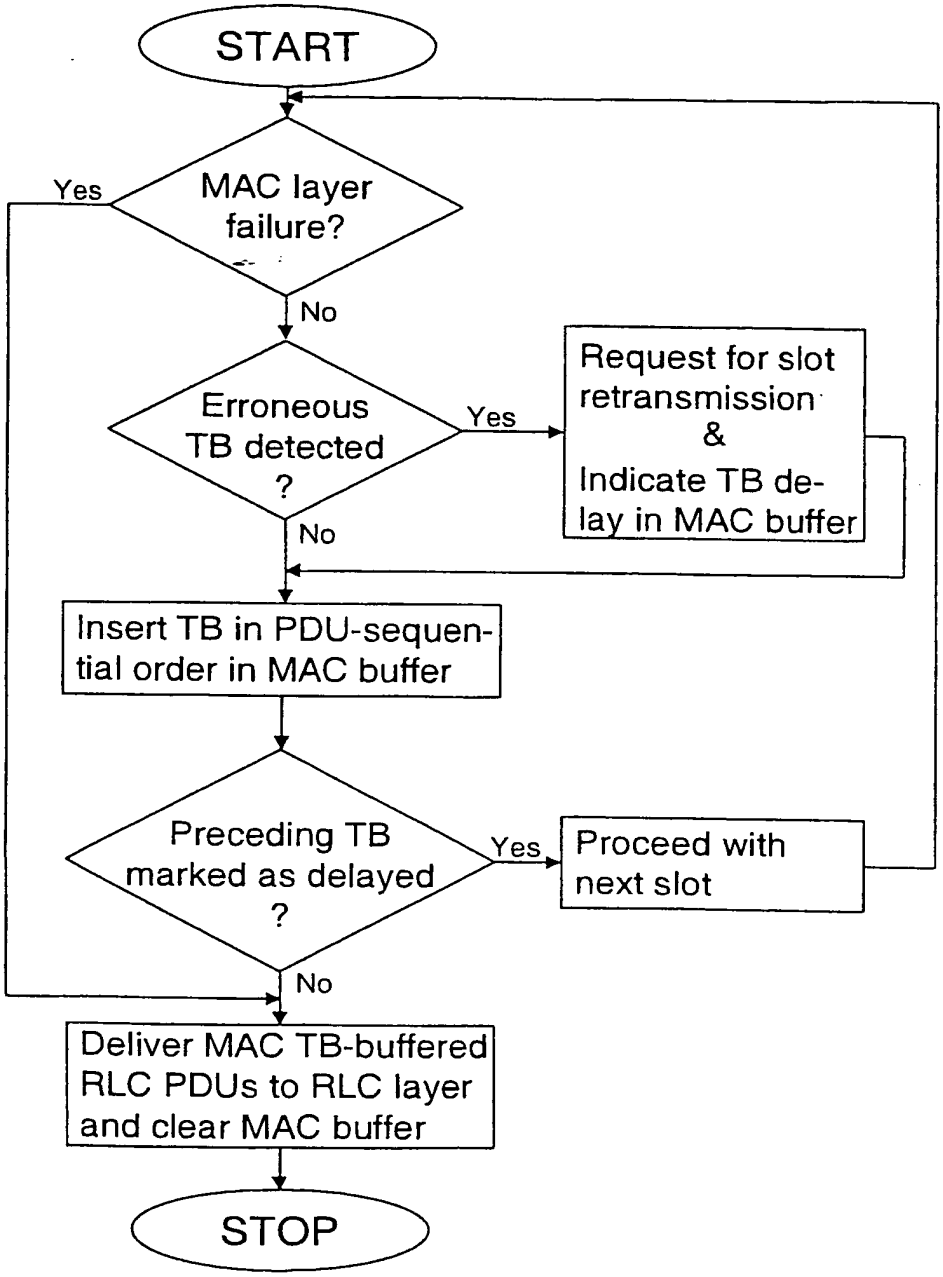
START
MAC layer failure?
Yes
No
Erroneous TB detected ?
Yes
Request for slot retransmission & Indicate TB de-lay in MAC buffer
No
Insert TB in PDU-sequen-tial order in MAC buffer
Preceding TB marked as delayed ?
Yes
Proceed with next slot
No
Deliver MAC TB-buffered RLC PDUs to RLC layer and clear MAC buffer
STOP

Fig. 9

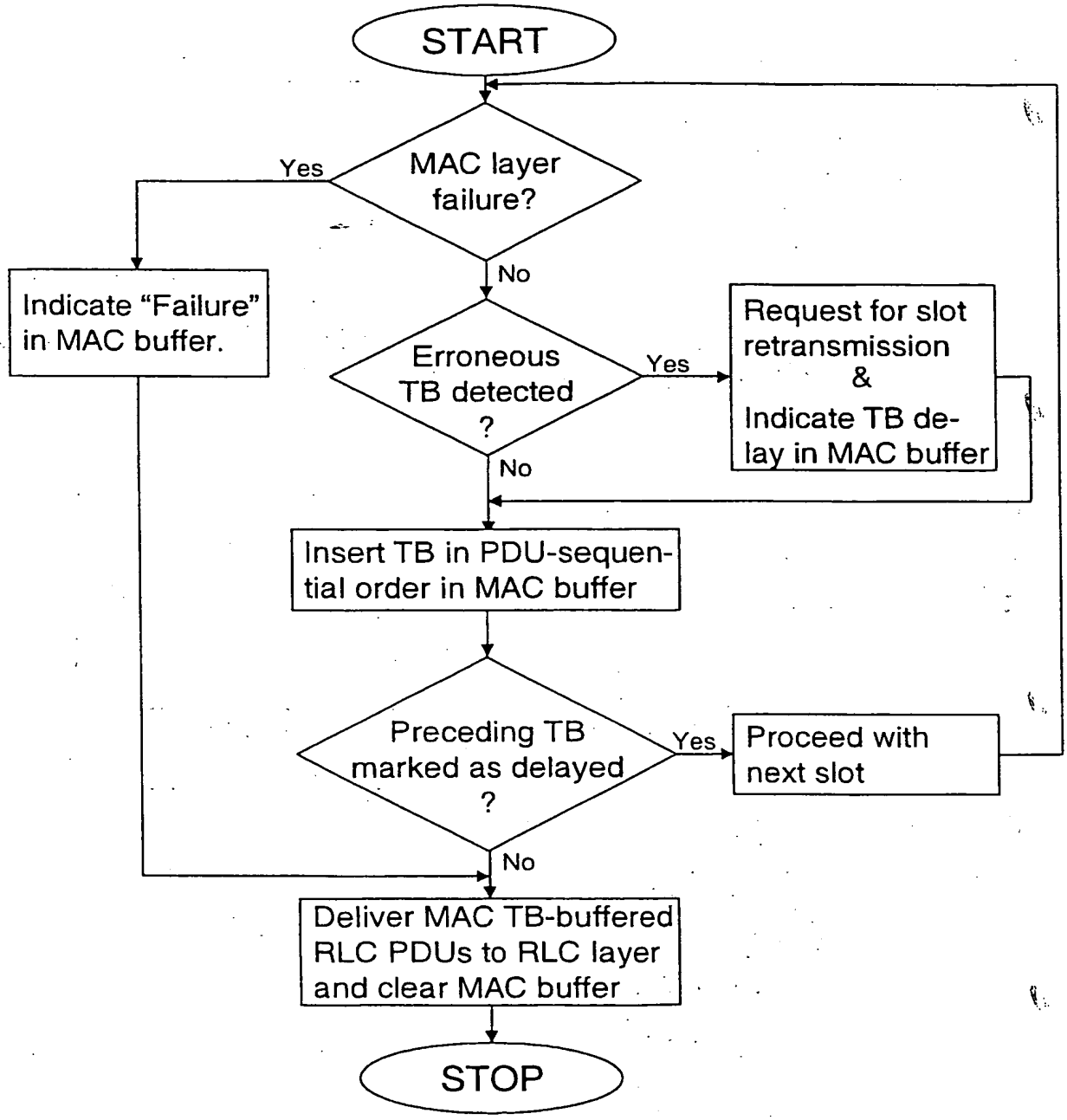
START
MAC layer failure?
Yes
No
Indicate "Failure" in MAC buffer.
Erroneous TB detected ?
Yes
Request for slot retransmission & Indicate TB delay in MAC buffer
No
Insert TB in PDU-sequential order in MAC buffer
Preceding TB marked as delayed ?
Yes
Proceed with next slot
No
Deliver MAC TB-buffered RLC PDUs to RLC layer and clear MAC buffer
STOP

Fig. 10

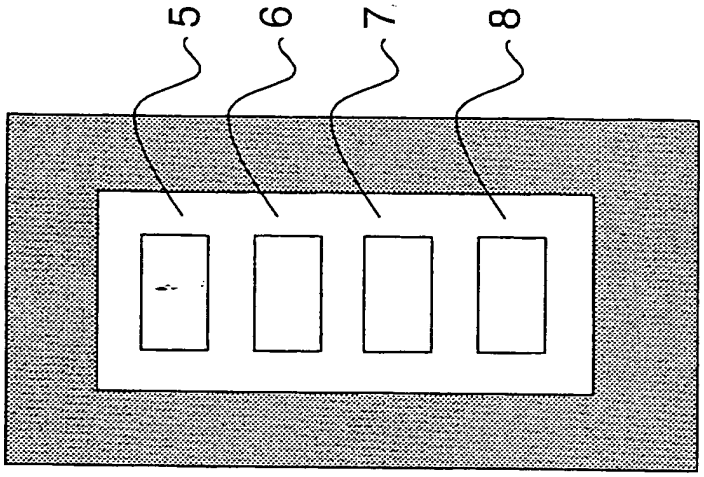

Fig. 12

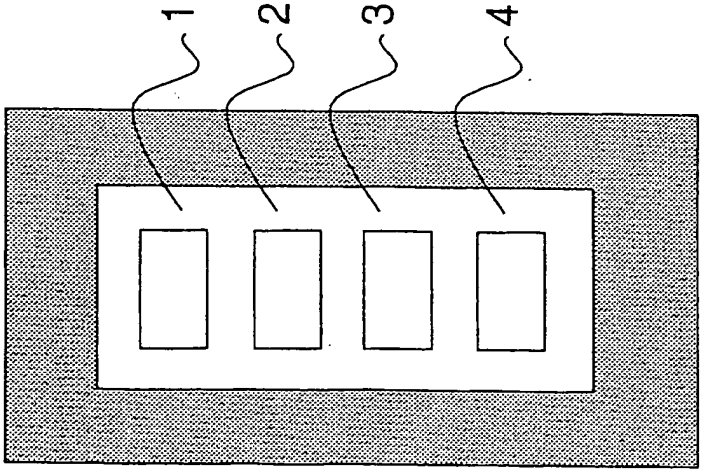

Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/00230

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04L 1/00, H04L 12/56, H04L 29/06
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6097731 A (AOKI, S.), 1 August 2000 (01.08.00), figures 1-4, claims 1-9, abstract, the whole document	1-5
Y		6-34
	--	
Y	WO 9903228 A1 (HUGHES ELECTRONICS CORPORATION), 21 January 1999 (21.01.99), page 1, line 1 - page 6, line 11; page 8, line 21 - page 9, line 24; page 10, line 21 - page 12, line 2, figures 1-5, claims 1-10, abstract	6-34
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 June 2002	14 -06- 2002
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Ismar Hadziefendic/LR Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/00230

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5677918 A (TRAN, P.M. ET AL.), 14 October 1997 (14.10.97), column 1, line 35 - line 40; column 2, line 6 - line 64; column 3, line 35 - line 64, claims 1,3-4,9,12-14, abstract -- --------	1-4,10-12, 15-16

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/05/02

International application No.
PCT/SE 02/00230

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6097731 A	01/08/00	GB 2318711 A,B	29/04/98
		GB 9722418 D	00/00/00
		JP 3001435 B	24/01/00
		JP 10136053 A	22/05/98
WO 9903228 A1	21/01/99	AU 8403898 A	08/02/99
		AU 8403998 A	08/02/99
		AU 8405498 A	08/02/99
		AU 8485698 A	08/02/99
		AU 8485798 A	08/02/99
		AU 8486698 A	08/02/99
		AU 8569798 A	10/02/99
		EP 0925655 A	30/06/99
		EP 0925656 A	30/06/99
		EP 0925657 A	30/06/99
		EP 0925658 A	30/06/99
		EP 0925662 A	30/06/99
		EP 0925706 A	30/06/99
		EP 0943187 A	22/09/99
		US 6233451 B	15/05/01
		US 6278876 B	21/08/01
		US 6282178 B	28/08/01
		US 6289482 B	11/09/01
		US 2001018348 A	30/08/01
		WO 9903212 A	21/01/99
		WO 9903213 A	21/01/99
		WO 9903214 A	21/01/99
		WO 9903215 A	21/01/99
		WO 9903296 A	21/01/99
		WO 9904510 A	28/01/99
US 5677918 A	14/10/97	NONE	